ICE THICKNESS IN THE MACKENZIE DELTA

WINTER 1985-86

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INTRODUCTION

The ice monitoring program in 1985-86 was similar to those of the past several winters (Sherstone 1984a, 1984b, 1985). Favourable weather conditions allowed early installation of all gauges. The first gauge was installed on East Channel, in front of the Town of Inuvik, on October 24, by which time the ice had attained a thickness of 19 cm. The last gauges were installed on West Channel on December 5th, about one month sooner than in the 1984-85 winter.

Reading of gauges continued throughout the winter and terminated on June 1, at which time the gauges were removed. As a result, the 85-86 winter represents the longest record of ice growth and decay in the study, approximately two months longer than previous records.

Despite the length of the winter the maximum thicknesses reached were generally less than those achieved in the 1983-84 and 1984-85 winters. This was due, in large part, to the relatively mild winter in the Delta.

INSTALLATION AND MONITORING

Installation commenced at the Inuvik Marina, on East Channel, with the installation of a gauge designed to monitor short-term variations in ice growth. Gauges at the normal locations on East Channel were installed on October 30 using snowmobile support. Because ice thickness was close to 30 cm at this location the balance of the gauges were installed using a four-wheel drive truck; Bombardier and Oniak being instrumented on November 8, Middle Channel (the last major channel to freeze-over) and Napoiak on November 29 and Aklavik and West Channels on December 5th.

All gauges were installed in identical locations to those of 1984-85 (Figure 1).

The final readings done from the ice roads were obtained on May 2. The gauges were read, using helicopter support on May 16, but ice and weather conditions favored continued ice growth so all were left in place. On June 1, final reading and gauge removal was completed. Break-up did not occur on East Channel at Inuvik until June 6th.

While in operation gauges 85-01 through 85-20 were read at 10-day intervals, when weather permitted. Gauge 85-101 (East Channel at Inuvik) was read at five-day intervals until destroyed by vandals in mid-April.

RELIABILITY

Failures and vandalism were much greater in 1985-86 than any previous year. Two gauges were broken by vandals (one several times) and one run over by a snowmobile. Four gauges failed during the winter. The timing of a gauge breakage, and locations of broken gauges was random. In each case the above-ice portion of the gauges appeared intact but the electrical circuit could not be completed.

It was not possible to determine the cause of failure but in three cases a different type and brand of insulated return wire had been used. Because of the unavailability of the normal, cold-flexible insulated wire a slightly thicker aviation wire was substituted and the insulation proved brittle when flexed at temperatures below -35°C. Most likely failure was caused by fatigue or ice impact, at the soldered joint of the insulated and resistance wire. Since water temperatures remain around 0°C the breakdown of insulation is not likely to be a major factor in failure.

A detailed discussion of gauge accuracy and performance can be found in a paper by Sherstone, Prowse and Gross (1986), presented at the Fourth Workshop on the Hydraulics of Ice-Covered Rivers.

DISCUSSION OF RESULTS

Maximum thickness values recorded in 1985-86 were generally less than those obtained in the 1983-84 and 1984-85 winters (Table 1). The exception was ice thickness on West Channel, which reached a maximum of 188 cm, 14 cm greater than any previous record.

Mean monthly maxima for the December to April period were consistently lower than in the previous year (Figure 2). This was caused by mild weather conditions which prevailed throughout most of the winter, compared to previous years (Figure 3). April temperatures were below normal and the effect of this was noticed in the increase of thickness of ice well into May. This was particularly evident in the records for East and Bombardier Channels.

Decay of the ice, slowed by cold weather in April, was further delayed during May by heavy snow accumulation caused by a major storm on May 11th. As a result, at the May 16th survey, ice at the gauge sites was covered by an average of 23 cm. of snow. As late as June 1, snow cover of over four centimeters remained at 11 of 20 sites, all located east of Napoiak Channel. While the winter was milder in 1985-86 than in previous years winds on the west side of the Delta were sufficient to remove most of the snow cover. This further increased ice growth for West Channel.

In 1985-86 none of the channels froze to the bottom at any of the gauge locations, despite the depths from ice surface to bed being similar in 1984-85 and 1985-86. No evidence of channel scouring was observed during 85-86 readings.

Also of interest is the relationship between mean maximum ice thickness and dates these mean maxima were achieved for each channel (Figure 4). Channels are clustered into two groups. The first comprises East, Bombardier and Middle Channels which are widely separated from a group consisting of Oniak, Napoiak and Aklavik Channels. Isolated from both groups is West Channel which achieves a greater maximum thickness than any other channel but achieves this thickness at a time intermediate to the other two clusters. The single factor which would explain clustering of channels into specific geographic sets is that of freeze-up date. Records provided by Mackay (1963) and Terroux (1981) indicates that the channels on the west side of the Delta freeze between 9 to 12 days in advance of east side channels and that Middle Channel freezes latest (sometime in early November). Given similar climatic conditions throughout the Delta the channels which freeze soonest would be expected to achieve greater ice thickness than later freezing channels.

Why, given earliest freeze-up dates, reduced snow cover and higher winds, West Channel achieves its maxima sooner (and therefore starts thinning sooner) is not known.

ACKNOWLEDGEMENTS

To Polar Continental Shelf Project, Department of Energy, Mines and Resources; for helicopter support at the time of final reading and removal of gauges.

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FIGURE 1

LOCATION OF ICE GAUGES , MACKENZIE DELTA , N.W.T.

WINTER 1985-86

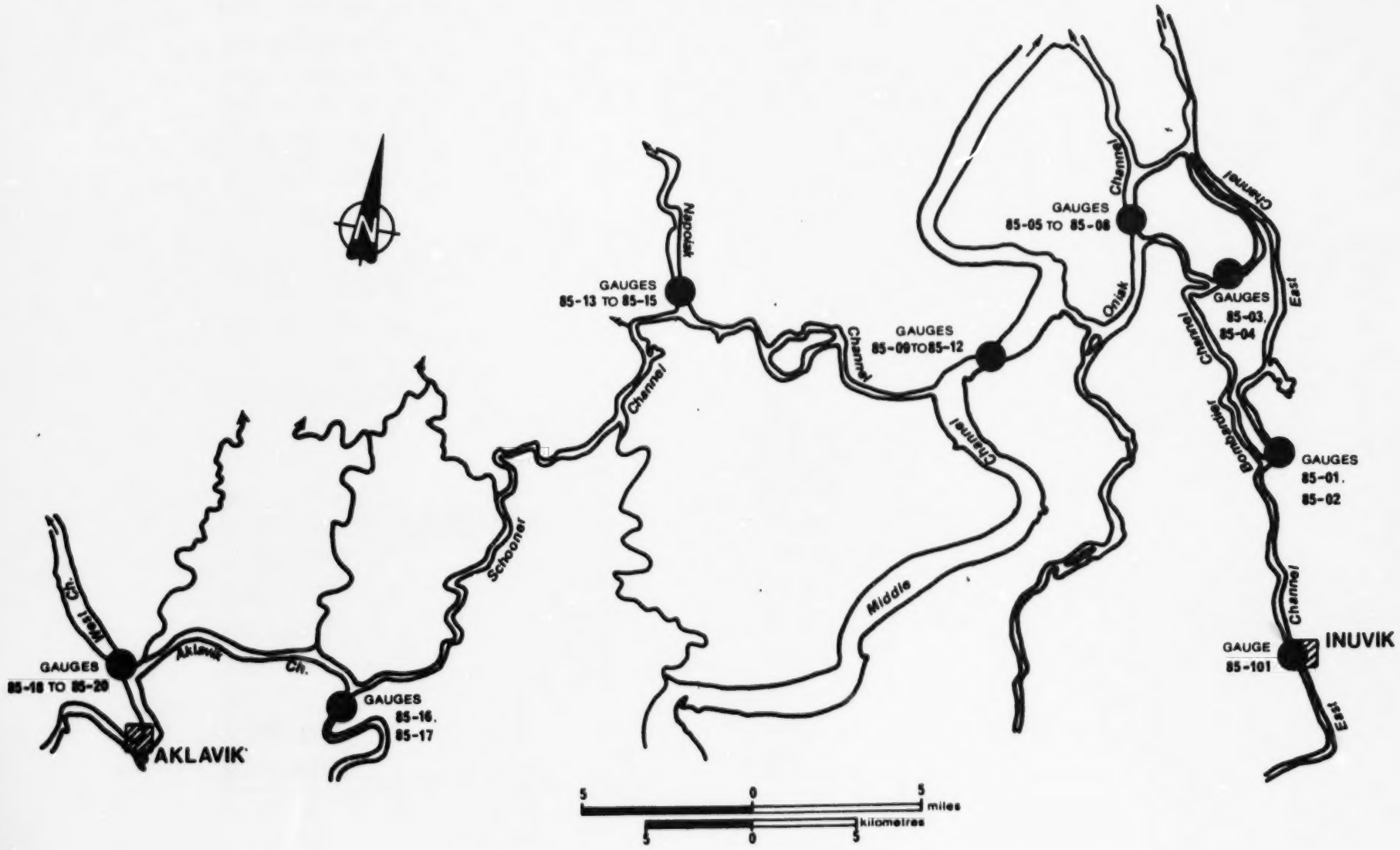

Figure 2

MEAN MONTHLY ICE THICKNESS FOR EACH RIVER CHANNEL MONITORED WINTERS : 1984-85, 1985-86

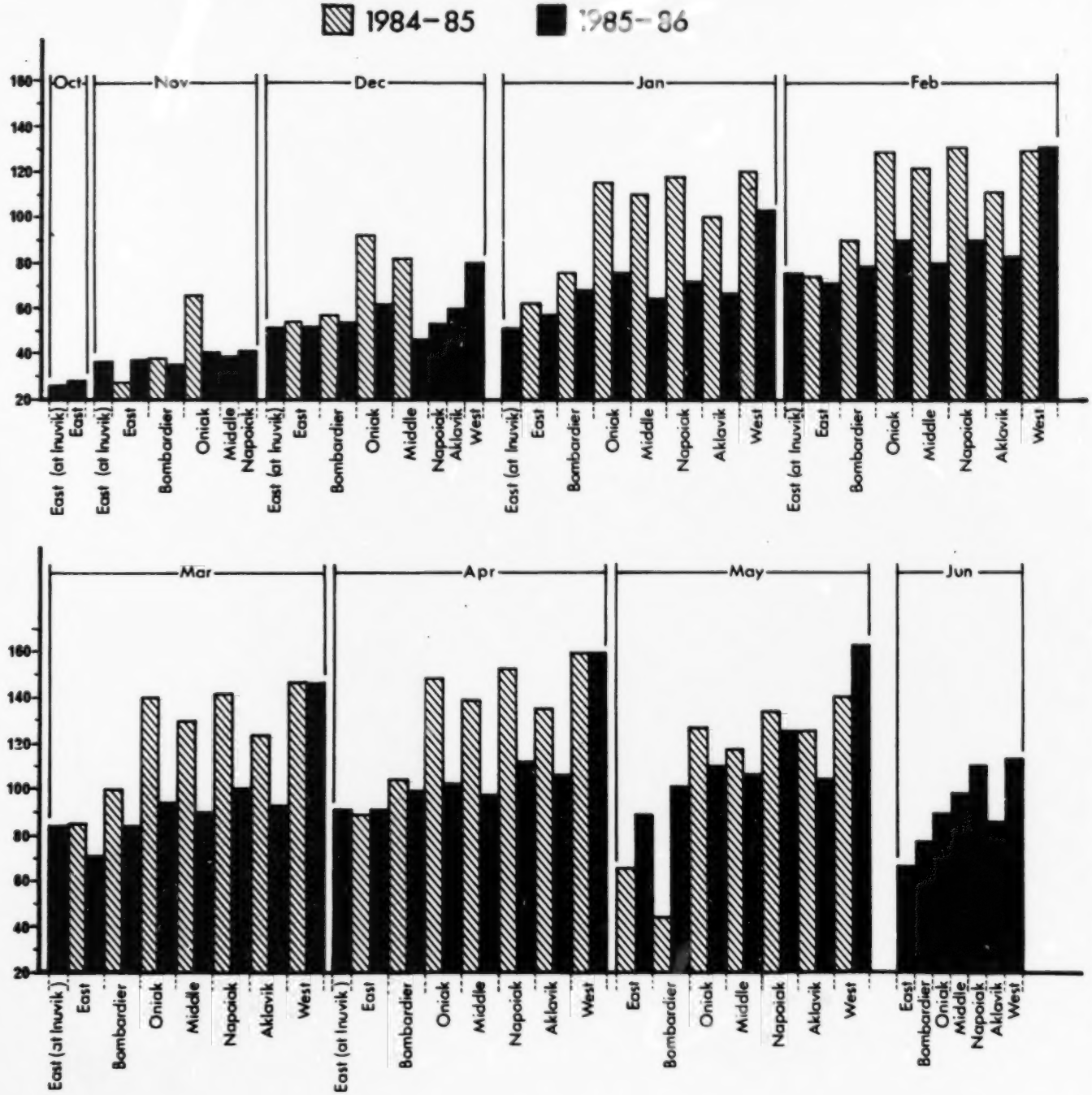

Figure 3

MEAN DAILY AIR TEMPERATURES (DEG. C)
INUVIK AIRPORT : WINTERS 1982-83 TO 1985-86
(FIVE DAY RUNNING MEAN)

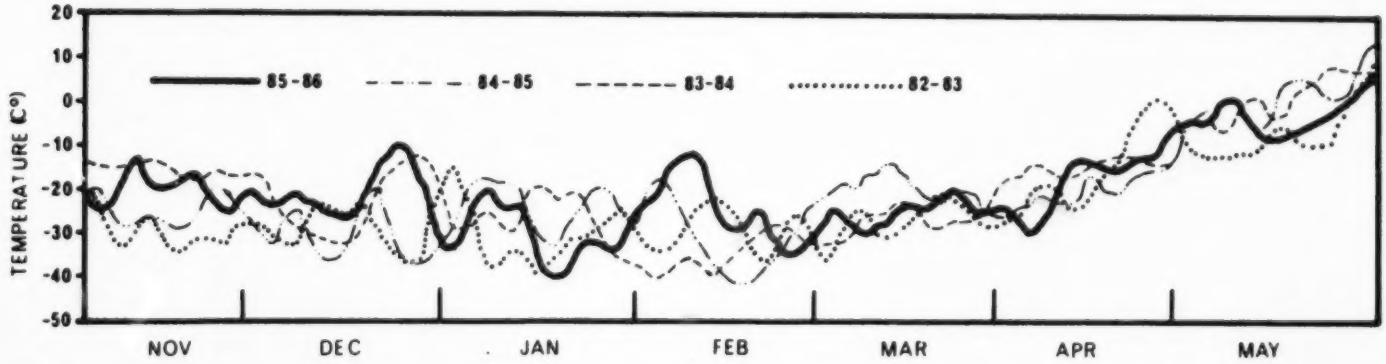

Figure 4

MEAN MAXIMUM THICKNESS AND MEAN DATE MAXIMA ACHIEVED : 1982-83 TO 1985-86

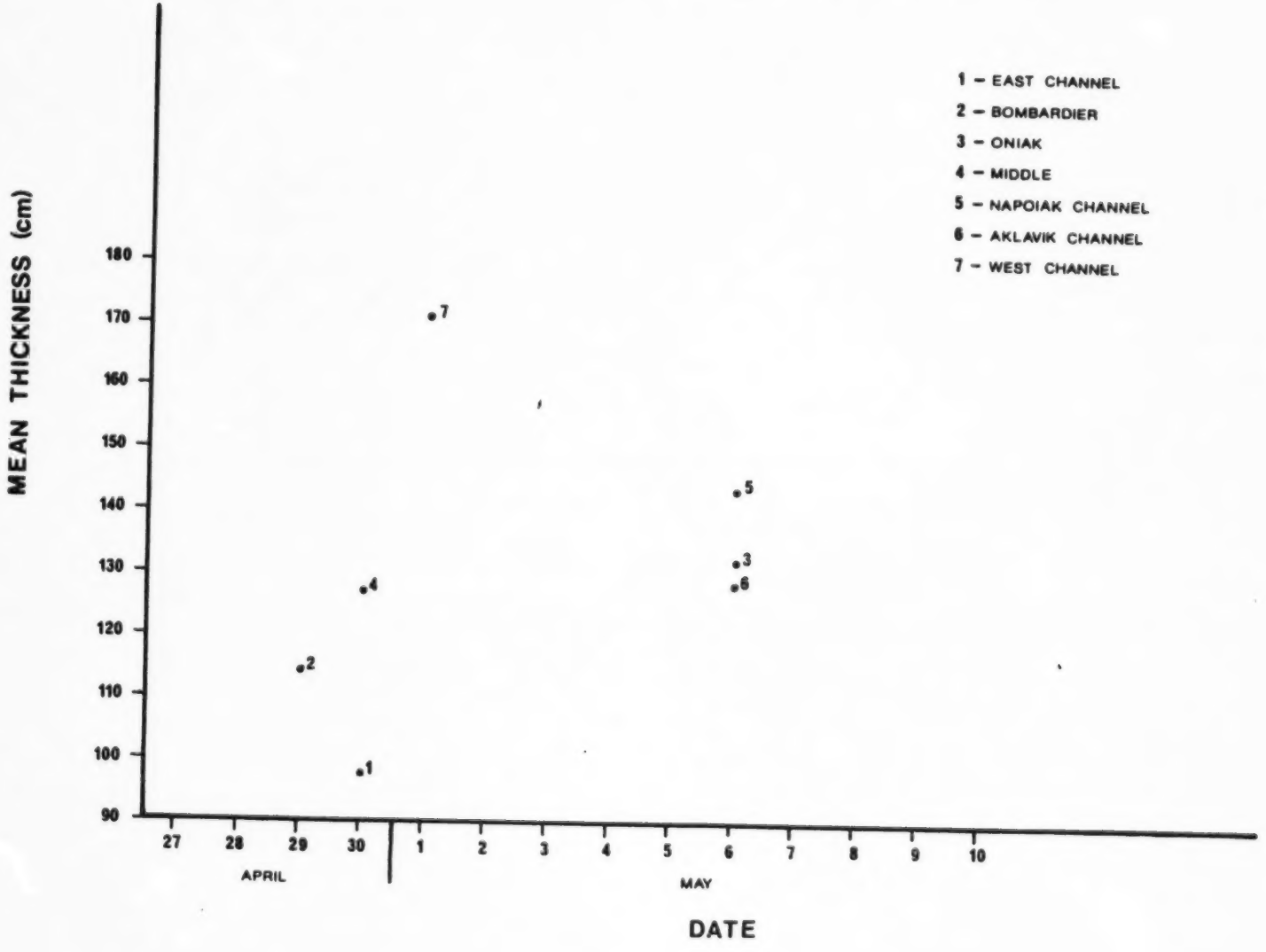

Table 1

MAXIMUM ICE THICKNESS

RECORDED ON EACH RIVER CHANNEL

WINTERS 1982-83 TO 1985-86

Channel	Winter	Thickness	Gauge	Date
East Channel	1982-83	98.0	82-14	April 12
	1983-84	105.0	84-02	April 27-May 3
	1984-85	95.5	84-02	April 29
	1985-86	92.5	85-02	May 2-May 16
Bombardier Channel	1982-83	n.a	-	-
	1983-84	113.0	84-03	April 27
	1984-85	111.0	85-103	April 29
	1985-86	120.0	85-04	May 2
Oniak Channel	1982-83	n.a	-	-
	1983-84	114.0	84-05	May 3
	1984-85	163.0	84-07	April 29
	1985-86	120.5	85-05	May 16
Middle Channel	1982-83	117.0	82-07	April 12
	1983-84	129.5	84-11	May 3
	1984-85	153.5	84-10	April 29
	1985-86	110.5	85-09/12	May 16
Napoiak Channel	1982-83	n.a	-	-
	1983-84	148.5	84-15	May 3
	1984-85	158.0	84-13	April 29
	1985-86	126.5	85-15	May 16
Aklavik Channel	1982-83	n.a	-	-
	1983-84	120.5	84-17	May 3
	1984-85	148.0	84-17	April 29
	1985-86	119.0	85-16	May 16
West Channel	1982-83	n.a	-	-
	1983-84	150.0	84-20	May 3
	1984-85	174.0	84-19	April 29
	1985-86	188.0	85-20	May 2

GAUGE DATA - MACKENZIE DELTA - 84-85

GAUGE 85-101

DATE	TOTAL ICE	WHITE ICE	SNOW
Oct 24	19.0	Nil	Nil
Oct 28	26.0	"	3.0
Oct 31	31.5	"	9.0
Nov 4	29.5	"	13.0
Nov 8	35.0	"	13.0
Nov 12	37.5	"	23.0
Nov 15	36.5	"	24.0
Nov 19	38.0	"	20.0
Nov 25	40.0	"	22.0
Nov 29	40.5	"	18.0
Dec 9	46.5	"	21.0
Dec 13	49.5	"	28.0
Dec 17	51.0	"	24.0
Dec 20	52.5	"	21.0
Dec 24	54.0	"	17.0
Dec 27	55.0	"	23.0
Jan 02	57.5	"	30.0
Jan 08	61.0	"	33.0
Jan 14	63.5	"	33.0
Jan 22	66.0	"	35.0
Jan 27	69.0	"	35.0
Feb 11	74.0	"	37.0
Feb 17	73.0	"	40.0
Feb 28	78.0	"	55.0
Mar 11	82.0	"	44.0
Mar 21	85.5	"	44.0
Apr 2	88.5	"	44.5
Apr 7	93.0	"	44.0
Apr 11	91.5	"	45.0
Apr 17	Destroyed by Vandals		

GAUGE 85-01

DATE	TOTAL ICE	WHITE ICE	SNOW
Oct 30	28.0	Nil	4.0
Nov 7	18.0	"	10.0
Nov 15	25.0	"	14.0
Nov 19	29.0	"	10.0
Nov 29	39.0	"	11.0
Dec 11	45.0	"	10.0
Dec 20	47.0	"	19.0
Jan 02	52.0	"	19.0
Jan 14	56.0	"	21.0
Jan 27	55.0	"	22.0
Feb 11	69.0	"	29.0
Feb 28	69.5	"	42.0
Mar 11	73.5	"	37.0
Mar 21	76.0	"	36.0
Apr 2	76.5	"	40.5
Apr 11	80.5	"	42.0
Apr 22	81.0	"	45.0
May 2	90.5	"	43.0
May 16	78.0	2.0	32.0
June 1	63.0	2.0	7.0

GAUGE 85-02

DATE	TOTAL ICE	WHITE ICE	SNOW
Oct 30	29.0	Nil	4.0
Nov 7	27.5	3.0	10.0
Nov 15	29.0	"	12.0
Nov 19	32.5	3.5	10.0
Nov 29	40.5	"	10.0
Dec 11	48.5	"	11.0
Dec 20	51.0	"	20.0
Jan 02	54.0	"	18.0
Jan 14	61.5	"	20.0
Jan 27	64.0	"	24.0
Feb 11	71.5	"	27.0
Feb 28	74.0	"	42.0
Mar 11	76.5	"	39.0
Mar 21	79.5	"	37.0
Apr 2	81.5	"	41.0
Apr 11	82.5	"	46.0
Apr 22	83.0	"	48.0
May 2	92.5	"	42.0
May 16	92.5	4.5	29.0
June 1	70.0	"	5.0

WINTER 85-86: GAUGE NO. 85-03

DATE	TOTAL ICE	WHITE ICE	SNOW
Nov 8	25.0	Nil	12.0
Nov 19	32.5	"	10.0
Nov 29	43.0	"	10.0
Dec 11	52.0	"	14.0
Dec 20	55.0	"	18.0
Jan 02	59.0	"	17.0
Jan 14	76.0	"	21.0
Jan 27	70.5	"	25.0
Feb 11	74.0	"	26.0
Feb 28	79.0	"	41.0
Mar 11	83.0	"	35.0
Mar 21	87.5	"	35.0
Apr 2	89.5	"	35.0
Apr 11	92.5	"	35.5
Apr 22	89.0	"	41.0
May 2	86.5	"	37.5
May 16	86.0	2.5	21.0
June 1	66.5	Nil	Nil

WINTER 85-86: GAUGE NO. 85-04

DATE	TOTAL ICE	WHITE ICE	SNOW
Nov 8	25.0	Nil	11.0
Nov 19	38.5	"	10.0
Nov 29	45.5	"	10.0
Dec 11	51.5	"	13.0
Dec 20	56.0	"	19.0
Jan 02	56.0	"	17.0
Jan 14	68.0	"	20.0
Jan 27	74.0	"	22.0
Feb 11	79.0	"	34.0
Feb 28	Broken	-	-
Mar 11	Broken	-	-
Mar 13	81.0	Nil	34.0
Mar 21	Vandalized	-	-
Mar 25	85.0	"	25.0
Apr 2	100.0	"	-
Apr 11	108.5	"	32.0
Apr 22	112.0	"	34.0
May 2	120.0	"	23.5
May 16	114.5	2.5	19.0
June 1	88.0	Nil	Nil

WINTER: 85-86: GAUGE NO. 85-05

DATE	TOTAL ICE	WHITE ICE	SNOW
Nov 8	36.0	Nil	10.0
Nov 19	43.5	"	9.0
Nov 29	53.5	"	10.0
Dec 11	63.0	"	10.0
Dec 20	70.0	"	18.0
Jan 02	74.5	"	15.0
Jan 14	80.5	"	20.0
Jan 27	86.0	"	20.5
Feb 11	91.5	"	22.0
Feb 28	97.0	"	39.0
Mar 11	101.5	"	32.5
Mar 21	105.0	"	32.5
Apr 2	108.5	"	31.0
Apr 11	112.5	"	31.0
Apr 22	115.5	"	34.0
May 2	117.0	"	33.0
May 16	120.5	3.5	32.0
June 1	95.5	3.5	11.0

WINTER 85-86: GAUGE NO. 85-06

DATE	TOTAL ICE	WHITE ICE	SNOW
Nov 8	34.0	1.0	10.0
Nov 19	40.5	"	13.0
Nov 29	49.5	"	11.0
Dec 11	60.0	"	13.0
Dec 20	65.0	"	19.0
Jan 02	68.0	"	19.0
Jan 14	74.5	"	24.0
Jan 27	78.0	"	27.0
Feb 11	83.5	"	28.0
Feb 28	87.5	"	36.0
Mar 11	93.0	"	32.0
Mar 21	95.0	"	33.0
Apr 2	100.0	"	32.5
Apr 11	104.0	"	32.0
Apr 22	107.0	"	36.0
May 2	106.5	"	36.5
May 16	114.5	9.0	27.0
June 1	92.0	7.5	6.0

WINTER 85-86: GAUGE 85-07

DATE	TOTAL ICE	WHITE ICE	SNOW
Nov 8	30.0	Nil	11.0
Nov 19	36.5	"	13.0
Nov 29	48.5	"	12.0
Dec 11	58.5	"	14.0
Dec 20	Not Working	"	20.0
Jan 2	"	"	20.0
Jan 14	"	"	24.0
Jan 27	"	"	-
Feb 11	"	"	-
Feb 28	"	"	-
Mar 11	"	"	-
Mar 13	89.0	"	41.0
Mar 21	68.5	"	40.0
Apr 2	90.5	"	45.0
Apr 11	95.5	"	44.0
Apr 22	100.5	"	45.5
May 2	107.0	4.0	39.0
May 16	110.5	8.0	20.0
June 1	88.0	3.0	10.0

WINTER 85-86: GAUGE 85-08

DATE	TOTAL ICE	WHITE ICE	SNOW
Nov 8	30.5	Nil	10.0
Nov 19	36.5	"	7.5
Nov 29	48.5	"	12.0
Dec 11	60.5	"	14.0
Dec 20	63.0	"	17.0
Jan 2	69.5	"	16.0
Jan 14	75.5	"	21.0
Jan 27	79.5	"	24.0
Feb 11	85.0	"	26.0
Feb 28	91.0	"	36.5
Mar 11	99.5	"	28.0
Mar 21	99.5	"	28.0
Apr 2	96.5	"	30.0
Apr 11	100.0	"	27.0
Apr 22	103.0	"	32.0
May 2	104.5	"	31.0
May 16	105.0	1.5	28.0
June 1	81.5	Nil	4.0

WINTER 85-86: GAUGE 85-09

DATE	TOTAL ICE	WHITE ICE	SNOW
Nov 29	41.0	Nil	8.0
Dec 11	46.5	"	10.0
Dec 20	53.0	"	15.0
Jan 2	59.0	"	14.0
Jan 14	68.5	"	18.0
Jan 27	73.0	"	20.0
Feb 11	78.5	"	20.0
Feb 27	84.5	"	23.5
Mar 11	90.0	"	23.0
Mar 21	96.5	"	33.0
Apr 2	99.5	"	26.0
Apr 11	114.5	"	30.0
Apr 22	107.0	"	29.5
May 2	109.5	"	25.0
May 16	110.5	2.5	25.0
June 1	98.5	2.5	8.0

WINTER 85-86: GAUGE 85-10

DATE	TOTAL ICE	WHITE ICE	SNOW
Nov 29	36.0	8.0	8.0
Dec 11	37.5	"	13.0
Dec 20	45.5	"	16.0
Jan 2	53.0	"	15.0
Jan 14	63.5	"	20.0
Jan 27	71.5	"	21.5
Feb 11	74.5	"	19.0
Feb 27	79.5	"	25.0
Mar 11	83.5	"	34.5
Mar 21	88.0	"	34.5
Apr 2	91.5	"	37.5
Apr 11	95.0	"	36.0
Apr 22	98.0	"	40.0
May 2	100.0	"	39.0
May 16	103.0	12.0	29.0
June 1	101.0	11.0	13.0

WINTER 85-86: GAUGE NO. 85-11

DATE	TOTAL ICE	WHITE ICE	SNOW
Nov 29	32.0	24.0	11.0
Dec 11	35.0	"	17.0
Dec 20	43.0	"	20.0
Jan 02	48.0	"	21.0
Jan 14	54.0	"	26.0
Jan 27	61.0	"	24.0
Feb 11	69.0	"	26.0
Feb 27	75.0	"	29.0
Mar 11	79.5	"	24.0
Mar 21	85.0	"	26.5
Apr 2	89.0	"	29.0
Apr 11	93.5	"	27.5
Apr 22	97.5	"	27.0
May 2	99.5	"	26.0
May 16	104.0	29.0	26.5
June 1	93.5	26.0	6.0

WINTER 85-86: GAUGE NO. 85-12

DATE	TOTAL ICE	WHITE ICE	SNOW
Nov 29	42.0	20.0	5.0
Dec 11	49.0	"	9.0
Dec 20	57.0	"	13.0
Jan 02	63.0	"	14.0
Jan 14	77.5	"	19.0
Jan 27	75.5	"	21.0
Feb 11	81.5	"	20.0
Feb 27	86.0	"	24.0
Mar 11	91.0	"	20.5
Mar 21	97.0	"	20.0
Apr 2	103.0	"	23.0
Apr 11	106.0	"	21.0
Apr 22	109.5	"	26.5
May 2	110.5	"	23.5
May 16	110.5	"	26.5
June 1	99.5	20.0	7.0

WINTER: 85-86: GAUGE NO. 85-13

DATE	TOTAL ICE	WHITE ICE	SNOW
Nov 29	40.0	Nil	8.0
Dec 11	49.0	"	9.0
Dec 20	55.0	"	8.0
Jan 02	62.5	"	10.0
Jan 14	70.5	"	20.0
Jan 27	75.5	"	20.0
Feb 11	82.5	"	28.0
Feb 27	89.0	"	28.0
Mar 11	94.0	"	21.5
Mar 21	97.0	"	22.0
Apr 2	104.0	"	32.5
Apr 11	107.5	"	31.5
Apr 22	Broken	-	29.0
May 2	"	-	28.0
May 16	"	-	22.0
June 1	"	-	Nil

WINTER 85-86: GAUGE NO. 85-14

DATE	TOTAL ICE	WHITE ICE	SNOW
Nov 29	41.0	Nil	11.0
Dec 11	44.0	"	14.0
Dec 20	58.5	"	12.0
Jan 02	59.5	"	13.0
Jan 14	77.5	"	19.0
Jan 27	76.0	"	18.0
Feb 11	83.0	"	17.0
Feb 27	90.5	"	20.0
Mar 11	97.5	"	19.0
Mar 21	102.5	"	19.5
Apr 2	107.0	"	22.0
Apr 11	112.0	"	21.0
Apr 22	116.5	"	23.0
May 2	120.0	"	22.0
May 16	120.0	2.0	16.0
June 1	105.5	2.0	Nil

WINTER 85-86: GAUGE NO. 85-15

DATE	TOTAL ICE	WHITE ICE	SNOW
Nov 29	42.0	Nil	9.0
Dec 11	53.0	"	9.0
Dec 20	59.0	"	9.0
Jan 02	65.0	"	11.0
Jan 14	76.5	"	16.0
Jan 27	83.0	"	19.0
Feb 11	89.0	"	16.0
Feb 27	97.5	"	21.5
Mar 11	103.5	"	15.5
Mar 21	109.5	"	16.0
Apr 2	113.0	"	18.0
Apr 11	119.0	"	18.0
Apr 22	124.0	"	18.0
May 2	125.0	"	16.0
May 16	126.5	3.0	19.0
June 1	115.5	3.0	Nil

WINTER 85-86: GAUGE NO. 85-16

DATE	TOTAL ICE	WHITE ICE	SNOW
Dec 5	47.0	Nil	10.0
Dec 20	56.0	"	13.0
Jan 02	62.5	"	15.0
Jan 14	69.5	"	18.0
Jan 27	75.5	"	22.0
Feb 11	82.5	"	20.0
Feb 27	89.5	"	31.0
Mar 11	94.0	"	21.0
Mar 21	100.0	"	21.5
Apr 2	106.5	"	23.0
Apr 11	110.0	"	27.0
Apr 22	115.0	"	27.0
May 2	115.5	"	26.5
May 16	119.0	4.5	18.5
June 1	94.5	3.0	Nil

WINTER: 85-86: GAUGE NO. 85-17

DATE	TOTAL ICE	WHITE ICE	SNOW
Dec 5	42.0	Nil	15.0
Dec 20	52.0	"	18.0
Jan 02	56.0	"	16.0
Jan 14	64.5	"	23.0
Jan 27	71.5	"	24.0
Feb 11	76.5	"	20.0
Feb 27	80.5	"	28.0
Mar 11	88.0	"	28.0
Mar 21	91.0	"	28.0
Apr 2	97.0	"	29.0
Apr 11	102.5	"	29.0
Apr 22	105.0	"	29.0
May 2	104.0	"	29.0
May 16	111.0	9.5	17.5
June 1	75.0	8.0	Nil

WINTER 85-86: GAUGE NO. 85-18

DATE	TOTAL ICE	WHITE ICE	SNOW
Dec 5	63.0	17.0	5.0
Dec 20	72.5	"	10.0
Jan 02	80.5	"	15.0
Jan 14	86.0	"	13.0
Jan 27	96.5	"	15.0
Feb 11	106.0	"	22.0
Feb 27	115.0	"	20.0
Mar 11	121.5	"	21.0
Mar 21	131.0	"	21.0
Apr 2	131.5	"	26.0
Apr 11	136.5	"	24.0
Apr 22	139.5	"	26.0
May 2	144.0	"	18.0
May 16	123.5	"	12.0
June 1	38.0	17.0	Nil

WINTER 85-86: GAUGE NO. 85-19

DATE	TOTAL ICE	WHITE ICE	SNOW
Dec 5	73.0	26.0	Nil
Dec 20	86.0	"	8.0
Jan 02	92.5	"	10.0
Jan 14	104.0	"	9.0
Jan 27	112.5	"	10.0
Feb 11	125.0	"	9.0
Feb 27	136.5	"	17.0
Mar 11	145.0	"	21.0
Mar 21	152.5	"	8.0
Apr 2	159.0	"	9.0
Apr 11	165.0	"	9.0
Apr 22	170.0	"	8.0
May 2	176.0	29.0	1.0
May 16	155.5	29.0	14.0
June 1	131.5	32.5	Nil

WINTER 85-86: GAUGE NO. 85-20

DATE	TOTAL ICE	WHITE ICE	SNOW
Dec 5	85.0	Nil	Nil
Dec 20	99.0	"	Nil
Jan 02	109.5	"	4.0
Jan 14	121.0	"	5.0
Jan 27	131.5	"	7.0
Feb 11	143.0	"	6.0
Feb 27	153.5	"	9.0
Mar 11	161.5	"	11.5
Mar 21	165.0	"	5.0
Apr 2	172.5	"	7.0
Apr 11	177.0	"	9.0
Apr 22	185.0	"	7.0
May 2	188.0	"	6.0
May 16	187.0	2.0	19.0
June 1	169.5	3.5	Nil